

Leaders

Factors contributing to low back pain in rowers

Competitive rowing is a highly aerobic sport requiring technical skills, motor coordination, adequate strength, and endurance.¹⁻² A number of authors¹⁻⁶ have reported a significant incidence of low back pain among the rowing population. This paper identifies the factors that may influence the onset of low back pain.

During the rowing stroke, the magnitude of the forces on the lumbar spine is high. Hosea *et al*⁷ reported average compressive loads of 3919 N for men and 3330 N for women, while anterior shear forces were found to be 848 N and 717 N for men and women respectively. Peak compressive loads during the stroke were 6066 N and 5031 N for men and women respectively. Furthermore, for 70% of the stroke cycle, rowers are in a flexed posture.⁷ Hosea *et al*⁷ recorded flexion ranges averaging 28–30° which equates to 55% of maximum range of spinal flexion. Tensile stresses on the outer annulus of the intervertebral disc have been found to increase considerably above 50% flexion.⁸ The combination of flexion with compressive loading has been identified as a mechanism for injury to the lumbar spine structures.⁹ In addition to flexion and compression, sweep rowers also rotate their trunks. This combination can place considerably more stress through the facet joint capsules and ligaments and may facilitate damage to discs, although the evidence for the latter is inconclusive.⁹ For rowers, the time of day will also influence the magnitude of the forces on their lumbar spines. In order to have calm water to row in, and to fit in with other daily commitments (work and study), a large volume of rowing is undertaken in the early morning. It is known that lumbar discs imbibe fluid from the surrounding tissue overnight when the disc is unloaded.¹⁰ Adams *et al*¹¹ calculated that the bending stresses are three times greater on the spine in the morning, and therefore this mechanism may make the disc and other ligamentous structures more vulnerable to injury in the morning particularly during activities involving flexion. Therefore it is suggested that repeated flexion and extension movements of the lumbar spine without load are undertaken at a slow speed for at least 60 seconds before rowing. Based on *in vitro* work,¹² 15 to 20 cycles of motion over this interval will decrease the bending moment by 8–10%. This motion should be undertaken in the sitting position that closely simulates the posture of the rower in the boat, and the range of motion should be gradually increased with subsequent repetitions. These exercises could also be undertaken on a rowing ergometer with the resistance set to zero.

It has been suggested that, during repetitive loading, compressive forces above 4000 N may cause damage to vertebrae.¹³ In industry, studies have shown that prolonged and cyclic flexion can result in a 10-fold increase in exposure to low back pain.¹⁴ The repetitive cyclic action of rowing may predispose the rower to low back injury. In a single session, a rower may train for 90 minutes and cover 20–25 km over that time. This amounts to about 1800 cycles of flexion per session. Although there is considerable variation, *in vitro* studies of repetitive loading have shown that damage can occur to lumbar vertebrae over a few hundred cycles of repetitive motion.¹⁵ Other researchers¹⁶ have suggested that injury to lumbar spine structures may occur when the bending moment on the lumbar spine exceeds about 23 N.m during repetitive motion. During everyday

lifting activities, the bending moment rises to about 18 N.m at L5-S1.¹⁷ In rowing, because of the larger loads on the spine and the influence of early morning training, it is likely that the bending moment is much higher.¹⁷

The repetitive motion of rowing may also induce creep in the soft tissues leading to a decrease in the stiffness of the tissues through the range of motion and an increase in the total range of motion in the lumbar segments.¹⁸⁻¹⁹ It has been suggested²⁰ that this process may ultimately lead to instability. Furthermore, repetitive motion can also desensitise the mechanoreceptors in spinal ligaments. These receptors often have pathways that lead to reflex activation of muscle.²¹ After repetitive motion, protective muscle activity has been shown to be reduced, often for a number of hours after the exercise is completed.²¹ The ramification for rowers is that, during this period, the athlete may be more vulnerable to injury, even when they may not be experiencing high loading on the spine.

Recently, it has been suggested that specific muscle activity can increase the stability of the lumbar spine. Research undertaken by Richardson and Jull²² and O'Sullivan *et al*²³ has focused on the importance of the transversus abdominus and the internal oblique abdominus groups, along with co-contraction of the multifidus muscles. These muscles have the potential to control the amount of movement in the lumbar segments, and their activation may therefore be useful in the prevention of low back pain in the rowing population. However, if these muscles are to control the amount of lumbar motion, they must be able to perform for long sustained periods. Roy *et al*²⁴ suggested that muscle fatigue may influence the incidence of low back pain in rowers. These researchers showed that rowers with low back pain became fatigued more easily than those without. Whether fatigue was a manifestation of the low back pathology or a factor that led to low back pain could not be determined. The ramifications of fatigue are related to the kinematics of the lumbar spine during the rowing stroke. If the erector spinae muscles are fatigued, the amount of lumbar flexion occurring during the rowing stroke may be increased, thereby increasing the bending moments on the spine. Such an increase may lead to additional strain on the passive structures of the spine such as ligaments and adjacent tissues.²⁴ More recently, Taimela *et al*²⁵ showed that fatigue of lumbar muscles affected proprioception. This study demonstrated that lumbar fatigue significantly impaired the ability of subjects to sense the position of their trunks when in flexion. For rowers, this may mean that, as they become fatigued, they may not be aware that they are moving into a more flexed posture.

Howell⁴ reported that 94% of rowers showed hypermobility of the lumbar spine, and this correlated strongly with the incidence of low back pain. It has been suggested⁶ that, to decrease the forces on the lumbar spine, rowers should adopt a less flexed lumbar spine, particularly at the catch phase when the oar is placed in the water. In this respect, if the pelvis could be rotated more anteriorly, less motion would be required in the lumbar spine. A major restraint to pelvic motion is the length and stiffness of the hamstring muscles. Studies by Gajdosik *et al*²⁶⁻²⁷ have shown that shorter hamstrings are associated with increases in range of lumbar and thoracic flexion. This has

consequences for rowing. If the athlete has short hamstrings, then to achieve the appropriate posture at the catch, he/she may overflex the spine. Hence it is important for rowers to include hamstring stretching exercises in their training programmes.

In summary, the large forces combined with the repetitive nature of the activity create the potential for injury to the lumbar spine structures during rowing. However, the warming up activities of rowers, the time at which they train during the day, the control of lumbar motion by specific muscle activation patterns, and the flexibility of the hamstring muscles can influence these forces. Incorporating these factors into training and rehabilitation programmes may lead to a reduction in the incidence of back injuries in rowers.

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Why exercise in paraplegia?

Spinal cord injury leads to two dramatic changes: not only is there loss of muscle function and a large amount of muscle, but also susceptibility to inactivity related diseases, such as obesity, insulin resistance, type II diabetes, and coronary heart disease, increases.¹ Previously, one of the major problems and causes of death for people with spinal cord injuries was infection, but recently, coronary heart disease has become more prominent. The possibilities for exercise in people with spinal cord injuries are limited to either performing voluntary exercise with non-paralysed muscle groups—for example, arm exercises, especially in the paraplegic—or subjecting themselves to electrically induced exercise through stimulation of motor nerves either with surface electrodes or after implantation of electrodes.

Whereas voluntary arm exercise can provide a certain stimulus to the cardiorespiratory system, it has recently been shown that stimulation of paralysed lower extremity muscles alone or in combination with arm cranking will not only increase energy combustion, but also activate more muscle groups and thus influence metabolic changes such as insulin resistance in a potentially better way. After the use of electrical stimulation for bladder and intestines, the possibility of stimulating paralysed muscle in a functional manner came to the fore at the beginning of the 1980s and allowed the development of a computerised bicycle (FES).² The use of such a bicycle for functional electrical stimulation has been shown not only to improve maximal oxygen uptake and endurance of the stimulated muscles, but also to cause muscle hypertrophy and muscle fibre shift from fast twitch type 2X to 2A.³

In addition to these effects, oxidative enzyme activity has also been shown to increase after several weeks of training.⁴ This occurs at a faster rate than the shift in fibre type, indicating different time patterns for the adaptation of these two systems. In addition, the collagen in muscle adapts to electrical stimulation, and it has been shown that type 4 collagen, which is predominant in the basal membrane, increases its turnover without any net increase in total amount, indicating possible reorganisation of this connective tissue.⁵ In addition to these effects, expression of the protein used for glucose transport (Glut4) increases with training and so does insulin stimulated glucose uptake in the muscle.⁶

Finally, it has been shown that functional electrical stimulation of paralysed legs increases bone mineral content of the tibial region. In studies using FES bicycling, high frequencies were used for stimulation, and no type I fibres were observed after this training. However, stimulation with lower frequencies actually seems to produce an increase in mRNA for myosin heavy chain type I after several weeks of training.⁷

In combination, the effects of functional electrical stimulation counteract the enzyme activity associated changes in people with spinal cord injuries and should thereby have a preventive effect.

In addition to these effects, electrical stimulation of partially paralysed muscle groups such as wrist extensor and muscles in tetraplegic people has been shown to result in improved function and endurance of the affected arm allowing more daily functions to be performed than before the training programme.⁸